Flight Systems Research Quarterly

An informal newsletter by and for participants of the UCLA/NASA Flight Systems Research Center

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X is for Experimental

Of all the prefix designations for aircraft, whether F, B, A, C, or what have you, the X designation has always carried with it a special fascination. Y, prototype, aircraft are also of great interest but once they enter mass production, the planes lose their original uniqueness and mystique. Only X-planes keep those qualities forever. Only a handful, if but one, of each are ever built. X designations are assigned by the DOD and include both piloted and remotely piloted vehicles. Some conceptual designs given X designations are so exotic and technologically advanced that they never make it from the CAD screen to the air, let alone the hanger floor.

The most famous X planes, known for their radical designs and milestone breakthroughs, are familiar names: the X-1 family of sound barrier breaking rockets, the X-15 trio of hypersonic aircraft that flew to the edge of space, and in more recent years, the X-29 and X-31 jet airplanes. The X-30, the National Aero-Space Plane, was a very ambitious program and produced a great wealth of research knowledge, but unfortunately will remain a paper study.

On the horizon, however, are two very promising X-planes which may very well capture the minds and imaginations of the American public by the end of the decade. The X-33 and X-34 are both technology demonstrator aircraft motivated by NASA's Access to Space initiative. These programs will pave the way for the next generation of reusable launch vehicles that could economically replace the aging Space Shuttle fleet. Whereas the X-33 will investigate the possibilities of single-stage-to-orbit, the X-34 will likely be an air-launched vehicle. It is hoped that the operational successor will lead a new era of space launch vehicles that avoid costly and complex ground support in favor of simpler, jetliner-like operations, and thereby expedite the commercial use of space.

For a more detailed description of the X-planes, read The X-Planes: X-1 to X-31, by Jay Miller, Aerofax, Inc., for Orion Books, Crown Publishers, New York, 1988.

NASA Associate Administrator Visits UCLA

Last November, NASA Associate Administrator for Aeronautics, Dr. Wesley L. Harris visited UCLA, where he stopped by the UCLA/NASA Flight Systems Research Center and the Minority Engineering Program office. Accompanied by Dryden Center Director Ken Szalai and SEAS Dean Frank Wazzan, Dr. Harris spent the morning delivering an open presentation at the Faculty Center and later talked to engineering students from both the FSRC and MEP. Also on hand were FSRC director, Prof. A.V. Balakrishnan and associate director, Dr. Ken Iliff, as well as Prof. K.L. Wang, EE department chairman.

L to R: EE graduate student Oscar Alvarez-Salazar, EE Prof. A.V. Balakrishnan, Dryden Chief Scientist Ken Iliff, Dryden Director Ken Szalai, NASA Associate Administrator of Aeronautics Wesley Harris, Dr. Harold Mortizavian, EE graduate student Gary Wilson, SEAS Dean A. R. Frank Wazzan, Dryden Technical Assistant Louis Steers, and Prof. K.L. Wang, EE Department chairman.

Dr. Harris is responsible for strategy, planning, advocacy and direction of NASA's Aeronautics research programs and for institutional management of NASA's Langley, Lewis, Ames, and Dryden Research Centers. Before assuming his current position in January 1993, Dr. Harris held a distinguished academic career with professorships at MIT, University of Connecticut, and University of Virginia, in addition to serving as advisor on several university committees.

In this issue

UCLA, NASA, WWW, and the Internet

Done any internet surfing lately? If so, perhaps you've stumbled across UCLA's World Wide Web (WWW) home page or maybe Dryden's or NASA headquarter's home page.

From your WWW browser (eg. NCSA Mosaic, Lynx, or Netscape), just connect to http://www.ucla.edu for UCLA's home page *"InfoUCLA",* where you can find anything from a professor's office phone to current course offerings to what's playing at the Wadsworth theater tonight. From the home page, you can also access other campus servers, like those for the EE department, MEMS group, MANE CAD lab, or the Center for Clean Technology.

To get to Dryden's home page, connect to http://www.dfrf.nasa.gov. From there you might want to explore NASA's general WWW server and find out about the latest Space Shuttle mission (STS-63) or anything else you ever wanted to know about America's official air and space agency.

Usenet users, if you've ever read the sci.aeronautics newsgroup, then you've seen the efforts of the moderator, Dryden's Mary Shafer, SR-71 project engineer in XRDD and UCLA alumna. While some newsgroups fall to the all too frequent flames of a few users (even in some .sci groups), sci.aeronautics has maintained a fairly healthy balance in attempting to keep the group engineering and technically oriented.

FSRC Research Roundup

Modeling of a Lobed Injector/Burner for NOx Reduction in High Speed and Advanced Subsonic Aircraft

L. Lance Smith, Olivier Delabroy, Ari Majamaki, Ivan Lam, Tim Gerk:
Profs. A. Karagozian, O. Smith Stephen Corda (XRP), Ken Iliff (X)

An experimental investigation of a lobed fuel injector is underway in the MANE Combustion Laboratory at UCLA. The injector is made of two plates which are planar and parallel at the upstream edge, and corrugated at the downstream edge. The plates are separated by a small gap, through which fuel flows (air flows above and below the plates). The injector geometry produces streamwise vorticity in the flow downstream of the injector, which provides rapid mixing of fuel with air. The streamwise vorticity also provides large fluid strain rates which prevent ignition at the fuel-air interface near the injector exit.

The lobed fuel injector is intended to provide partially premixed combustion at a finite distance downstream of the injector exit, where fluid strain rates are small enough that combustion may occur. By burning fuel in a fuel-lean, partially premixed environment, flame temperatures and thermal NOx production may be reduced.

Planar Laser Induced Fluorescence (PLIF) images of acetone fluorescence have been made at UCLA to measure mixing in the lobed fuel injector. Acetone was seeded in CO2 (representing fuel, for mixing purposes), and the injector was operated inside of a low-speed wind tunnel without combustion. A scalar dissipation field was calculated from the images of fuel concentration, and the results show that fluid strain rates are sufficient to prevent ignition near the injector exit.

Modeling of High Mach Number Flows for Pegasus

E. David Huckaby and John Mendoza:
Prof. I. Catton (MANE) Bob Curry (XRA)

A basic two-layer conduction model has been developed to improve the prediction of surface heat fluxes and allow for temperature variations across the surface. In the thin wall normal direction, a second-order in space, implicit in time is used to alleviate severe time-step restriction. This results in a tri-diagonal system at each body surface location. The tri-diagonal system can be solved with a slight computational penalty over an explicit method. Along the Pegasus surface a second-order explicit scheme is used. Currently the model is being verified independently of the Computational Fluid Dynamics (CFD) code but will be implemented in place of the constant temperature boundary condition at the surface.

At the symposium it was suggested that further verification of the PARC3D code was necessary due to the uncertainty in the heat flux and pressure measurements of the HRSI plugs. Currently we are using the PARC3D code to calculate a two-dimensional shock-wave/boundary-layer interaction problem and comparing the results against detailed experimental data. The performance of PARC for this flow situation will identify problems the CFD code has near the shock/body fillet junction where there is the possibility of shock/boundary layer interaction. Further tests of a three-dimensional shock/boundary-layer interaction problem will follow

Leading Edge Cooling Studies -- Grooved Capillary Evaporators

Gustave Stroes
Profs. I. Catton, V. Dhir Bob Curry (XRA)

The semi-analytical model that was developed for the triangular groove geometry is now being extended to the sinusoidal shape. The model predicts the distance to which liquid will be drawn up an inclined groove subject to a heat input from below.

Speyer Awarded AIAA Dryden Lectureship

Professor Jason Speyer of UCLA's Mechanical, Aerospace, and Nuclear Engineering Department was awarded the 1995 Hugh L. Dryden Lectureship in Research at the 33rd Annual AIAA Aerospace Sciences Meeting and Exhibit in Reno, NV.

The Dryden Lectureship in Research "emphasizes the great importance of basic research to advancement in aeronautics and astronautics and is a salute to research scientists and engineers."

The Lectureship is named in honor of Dr. Hugh L. Dryden, aerospace pioneer and scientist. In 1949, Dr. Dryden was named to the newly created post of NACA director. When NACA became NASA in 1958, Dryden remained on as deputy administrator until 1965. The present Dryden Flight Research Center was named in his honor in 1975.

Prof. Speyer's presentation, titled **Periodic Optimal Flight** (AIAA 95-0001), dealt with the theory and formulation of optimal control applied to periodic flight trajectories, in contrast to conventional steady-state cruise paths, resulting in improved performance and fuel efficiency.

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This distance is termed the wetted length and gives an estimate of the groove's resistance to dryout which is important in a heatpipe-type application. The model for the triangular shape was shown to agree quite well with the previously obtained experimental data. Since experiments had also been conducted with the sinusoidal shape, the next step was to construct a model for that case. Although development of the sinusoidal model follows the same path as the triangular model, the geometry becomes much more complicated. For example, there is no explicit expression relating the radius of curvature of the liquid-vapor interface to the liquid height. An iteration scheme is necessary which was not required for the triangular case. None of the complications are insurmountable, it just means that a greater reliance on numerics will be necessary. The triangular model yielded an almost entirely analytic solution - which was aesthetically attractive. The triangular model will be presented at the International Heatpipe Conference in Albuquerque in 1995 and the sinusoidal model will hopefully be finished in time for the National Heat Transfer Conference in Portland (1995).

Estimation of Wind Profiles from Laser Beam Propagation Distortion
Oscar Alvarez-Salazar, Dennis Braunreiter, Charles Chang,
Gary Wang, Gary Wilson
Prof. A.V. Balakrishnan **Ken Iliff (X)**

This project has the objective of developing a non-intrusive method for monitoring as well as measuring wind velocity based upon forward laser beam scattering phenomena. The group's recent activities can be classified into four areas: improvement of the experimental set up, development of theory to resolve wind velocity along the path of the beam, use of extended Kalman filtering & MLE (maximum likelihood) theory for measuring wind velocity, and improvement of experimental repeatability.

The experimental set up was improved as follows. A 10 channel circuit board was built to accommodate the new photo detector array. A rotary assembly to host the photo detectors is now in place. A data acquisition/DSP board was purchased to achieve greater sampling rates and computational speeds. A Newport (8 by 4 ft) pneumatically isolated optical table was brought in to replace a less adequate table for the detectors. A blower capable of delivering up to 12 m/s wind velocities was brought to compare it to the existing fans. A digital wind velocity meter was purchased as an alternate mean of measuring wind velocity.

The theory developed to resolve wind velocity along the path of the beam was based on the position of the focal point of the beam. Experiments to confirm and tune the theory are currently being conducted.

Extended Kalman filtering & Maximum Likelihood Estimate algorithms were implemented to estimate simulated wind velocity profiles. Good results were obtained with the simulated data. Next, data collected in the lab will be used along with better models of the system.

Experimental repeatability was greatly improved by establishing a recalibration procedure of the circuit board every time the laser or the laser's position is changed.

Probabilistic Risk Assessment and Management in Support of NASA
Chris Garrett
Prof. Apostolakis and Prof. Catton **Vicki Regenie (XRD)**

Work is currently in progress to develop a DFM (Dynamic Flowgraph Methodology) model of the HARV F-18 RFCS flight control system. The model represents causal and timing relationships between software functions, interfacing hardware, and external system parameters. The system is very complex, and, so far, the model

Research Roundup, continued from page 3...

contains more than one hundred nodes. We recently obtained the HARV simulator, which we will use to develop decision tables which, as input to the DFM analysis, will result in the development of fault trees which identify system failure modes resulting from combinations of software logic errors, hardware failures and environmental conditions.

Human-Computer Interaction in Complex Systems
Eric Shank
Prof. W. Karplus **Mary Shafer (XRDD)**

Eric Shank has been working on parameterized synthesis of sounds for his spatialized auditory display. He is investigating different methods of synthesis and hardware and software platforms to implement them. The technology was demonstrated for Tom Cord of Wright-Patterson Air Force base. Next up, Eric plans to test a simple spatialized version of control room audio with Dryden engineers. Eric remains on-sight at Dryden through the winter quarter.

Fluid Flow & Heat Convection Studies for Actively Cooled Airframes
Brian Dempsey and Ben Tan
Prof. A. Mills **Bob Quinn (XRS)**

Since the last update, the jet impingement heat transfer experiment has been further improved by increasing the rate at which data and images are collected by the computer. All aspects of the design have been completed, and data was collected in a series of parameter studies so that the results could be compared to published jet impingement data. Discrepancies were small near the stagnation point but away from the stagnation point, heat transfer coefficients were significantly lower than the published data due to the heated jet entraining ambient air. For internal flow, such as the backside of the leading edge of a hypersonic aircraft, entrainment does not exist and therefore will not effect the results. For future plans, the data acquisition and the data reduction programs will be integration into a single heat transfer analysis package and the experimental procedure will be further automated by controlling the power supply from the computer. Once completed, the package will be used to determine the heat transfer characteristics for the leading edge of a hypersonic aircraft.

{As a reminder, students are encouraged to submit research summaries at the beginning of each quarter for entry into that quarter's newsletter. One hundred words or less is the suggested length for the summary. E-mail reminders will be sent out as usual near the end of the prior quarter.}

Useful Phone Numbers at Dryden

The following is a list of NASA personnel associated with the UCLA/NASA Flight Systems Research Center and their Dryden phone numbers alongside. Feel free to contact any of them regarding issues related to your research. In addition to the personal help of it's engineers, Dryden continues to make available many of its resources to participants of the FSRC. Need to borrow a pressure transducer or accelerometer? Or a laser or two? Or a wind velocity meter? Need some instruments calibrated? Want to use Dryden's quartz heat lamp facility, water tunnel, or environmental laboratory? Need a Dryden computer account? Need to run any NASA-developed software? Want access to flight or meteorological data? Need some special hardware machined or fabricated? Can't find a technical report or book at UCLA? How about flying an experiment on a double or triple sonic research aircraft? These and more resources and capabilities are just a phone call away.

Name	Research Branch	Phone Number
Karl Anderson	Thermostructures	805-258-3549
Rodney Bogue	Flight Instrumentation	-3193
Al Bowers	Aerodynamics	-3716
Marty Brenner	Structural Dynamics	-3793
Bill Burcham	Propulsion and Performance	-3126
Bob Clarke	Dynamics and Controls	-3799
Stephen Corda	Propulsion and Performance	-2103
Bob Curry	Aerodynamics	-3715
Mike DeAngelis	Thermostructures	-3921
Dwain Deets	Research Engineering	-3136
Jack Ehernberger	Aerodynamics/Meteorology	-3699
Roger Fields	Thermostructures	-3929
Dave Fisher	Aerodynamics	-3705
Bob Geenan	Aerodynamics	-2265
Joe Gera	Dynamics and Controls	-3795
Kajal Gupta	Research Engineering	-3710
Phil Hamory	Flight Instrumentation	-3090
Ken Iliff	Chief Scientist	-3314
Steve Johnson	Propulsion and Performance	-3096
Bob Meyer	Research Engineering	-3707
Tim Moes	Aerodynamics	-3054
Greg Noffz	Aerodynamics	-2417
Bob Quinn	Thermostructures	-3582
Vicki Regenie	Flight Systems	-3430
Pat Seamount	Flight Controls	-2031
Mary Shafer	Flight Dynamics	-3735
Steve Thornton	Thermostructures	-3024
Charles Wang	Aerodynamics	-2107
Tony Whitmore	Aerodynamics	-2002

{Most, if not all, of the people listed above also have internet accounts. Please call them for their account name if needed.}